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VII.—*On some Blind Amphipoda of the Caspian Sea.*

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The problem of the origin and evolution of blind animals has occupied the attention of many naturalists of late; and their investigations have contributed to science many facts of the greatest importance. The number of these discoveries has been further increased by the deep-sea investigations, which have brought to light some extremely interesting forms from enormous depths. But when we consider the already great number of blind animals, we cannot help constantly raising the question of their origin, as even now two opposite opinions prevail, which exclude each other and cannot be reconciled.

Twenty years ago one might have been contented with the dogma that the creatures were created blind because they were intended to live in dark caves and the abysses of the sea, and therefore the faculty of sight was unnecessary to them. Nowadays, however, this notion is supported by few professed naturalists: the great majority recognizes in the absence of eyes in certain animals the result of a residence in darkness, by which means the visual organ must certainly become retrograde, as it cannot be and is not made use of. Besides Frics's experiment with *Gammarus pulex*, it is well known that persons who have been compelled to languish out a long

* Translated by W. S. Dallas, F.L.S., from the 'Archiv für Naturgeschichte,' 1880, p. 117.

series of years in dark prisons have lost the pigment of their eyes, and when brought once more into the open could not for a long time distinguish objects, but rather suffered pain from the daylight, as also that "in many blind people the eyes have literally disappeared. In the bodies of men who were perfectly blind when alive we even find that the optic nerve has disappeared up to the brain, *i. e.* transformed into a mass which contains no visual-nerve fibres" (Stricker, 'Studien über das Bewusstsein,' p. 54). Thus it appears very natural that animals which live in dark caves, wells, sea-abysses, or in the earth itself should lose their power of vision, their eyes being reduced to almost nothing—as, indeed, is indicated by the fact that eyes are often still present although only rudimentary, such as we find, for example, in *Sorex* and *Talpa*.

But we know that in the depths of the sea where some eyeless animals occur, whose deprivation of eyes is explained by the darkness prevailing in those abysses, there also exist forms which have not merely ordinary eyes, but unusually developed, large, prominent, and strongly pigmented eyes. Nay, the *Gnathophausia* of the 'Challenger' Expedition, coming from a depth of from 1830 to 4020 metres, actually possesses pedunculate eyes, and, besides these, ocelli on the maxillæ; the *Memida* from a depth of 1000–1200 metres has well-developed and exceedingly sensitive eyes; while *Gammaracanthus caspius*, mihi, from a depth of 108 fathoms in the Caspian, *Boeckia spinosa*, *nasuta*, and *hystrix*, mihi, from depths of 70–150 fathoms in the Caspian, and various species of *Mysis* from the same sea and from depths down to 500 fathoms, all have well-developed, large, prominent, and black-pigmented eyes. This sufficiently proves that at the depths indicated the visual organ can be and is made use of, as here absolute darkness does not prevail, but only a dark night. We have only to remember that nocturnal animals, such as the owls, predacious mammals, &c., possess very large and well-developed visual organs (in fact, eyes adapted to the darkness), to explain the established fact that the depths of the sea are inhabited by crustaceans in which the visual faculty is enormously increased. But seeing that, as has been said, forms of animals also exist in the same abysses whose eyes are but slightly developed or unpigmented, or even appear completely reduced to a rudimentary condition, it is evident that the explanation that the retrogression of the eyes is produced by living in the depths of the sea is not sufficient.

In the Caspian Sea, at 0° 12′ E. long. (from Baku) and 39° 51′ N. lat., I obtained in a single cast of the dredge ten new species of Gammaridæ (namely *Gammarus pauxillus*, *G.*

crassus, *G. Gregrokowii*, *G. portentosus*, *G. coronifer*, *G. thaumops*, *Pandora cæca*, *Iphigeneia abyssorum*, *Gammaracanthus caspius*, and *Amathilinella cristata*), all of which are furnished with eyes, but in very different degrees of development: thus *Gammaracanthus caspius* has very large round eyes, *Gammarus coronifer* and *Amathilinella cristata* long but narrow eyes, *Gammarus thaumops* triangular unpigmented eyes, and *Pandora cæca* small unpigmented eyes, which can hardly be endowed with the faculty of sight. A still better example is furnished by the following new Amphipoda discovered by me in the Caspian Sea:—

			fathoms.
Onesimus caspius	from the depth	of	75–250
—— *pomposus*	„	„	180
—— *platyuros*	„	„	40–48
Pantoporeia microphthalma	„	„	80–90
Niphargus caspius	„	„	35–90

of which the last two species, together with *Onesimus caspius*, were also taken in one cast, and, indeed, at a depth of 80–90 fathoms, at 0° 36′ E. long. and 41° 6′ N. lat. *Pantoporeia microphthalma* and *Niphargus caspius* possess pigmented but small eyes; of the species of *Onesimus* some possess red, others (*O. caspius*) perfectly unpigmented eyes, which, in the last-mentioned species at least, are deprived of the faculty of sight; and with these more or less blind species there live Mysidæ, the large, convex, and black eyes of which certainly absorb a sufficiency of light even in the darkness of the depths.

These examples may suffice to show that deep-sea existence alone does not of necessity cause the retrogression of the visual organ. Now, however, we will show from our Caspian Amphipoda, how the animals stand related to the sea-depths, how deep-sea existence acts upon their organization, by what essentially the disappearance of the eyes is brought about, and by what the latter are replaced in the event of their retrogression.

We may accept it as proved that with the increase of the depth of the sea the quantity of rays of light diminishes, so that at a certain distance from the surface the strength of the light is very small, although it never falls to zero. But, however weak the light may be, the possibility of vision is not excluded, and the eyes of animals living in the abysses need only to be adapted to the comparative darkness*. Such

* I think it doubtful that absolute darkness commences at a depth of 100 metres, as found by Forel in the lake of Geneva; for I cannot at all conceive of absolute darkness. I readily admit that at this or the other depth the daylight no longer reacts upon certain chemicals; but this does not exclude the possibility of seeing.

appears to be the case with the large, gibbose, dark eyes of Caspian Mysidæ, of *Gammaracanthus caspius*, the species of *Boeckia*, &c. It is, however, conceivable that in many animals in the persistent darkness the eyes do not become developed and are replaced by other organs of sense. In the latter case the eyes may even become degenerated, and the more rapidly and completely the less they are used, the less the service they render or are capable of rendering to their possessor. We may take as examples *Niphargus caspius** and the above-mentioned species of *Onesimus*.

In examining these we find highly developed sense-organs, which probably function not only as organs of touch, but also (at least in the species of *Onesimus*) as organs of taste †.

Besides small, but dark-pigmented eyes, which can probably hardly function at depths of 35–90 fathoms, and which must be regarded as the remains of eyes which formerly functioned, *Niphargus caspius* has exceedingly well-developed organs of smell and touch on the antennæ, and especially on the upper ones. At the same time it is to be remarked that the males, which have the smaller eyes, possess a greater number of these sense-organs than the females, which, with respect to other characters also, *e. g.* the number of joints in the secondary

* From this species *N. putcanus* is probably derived. It is possible that it is identical with *N. ponticus*, Czern.; unfortunately I have been unable rightly to determine the latter, as the description which M. W. Czernjewsky has given of it appears to be very defective. (See his 'Materialia ad monographiam ponticam comparatam.') It must, however, be remarked that our *N. caspius* differs in many respects from the other species of *Niphargus*, and, indeed, from *N. putcanus*, as in its shorter antennæ, the differently formed hand of the last pair of limbs, &c.; so that, perhaps, our species may be regarded as the representative of a new genus between *Niphargus* and *Gammarus*. I do not take this course, however, and recognize in the different organization of *M. putcanus* the expression of a further development under the influence of certain conditions, which have superinduced the deficiency of the eyes and, at the same time, the greater development of the antennæ which bear the sense-organs that take the place of the eyes. In any case, *Niphargus caspius* appears to be the older form, which has maintained itself (perhaps somewhat altered) in the Caspian down to the present time, just as other species of the Tertiary period still continue to exist there, as I have indicated in my 'Kaspischen Fauna,' Lief. ii., in the case of *Dreissena rostriformis, D. Brardii, D. caspia, Cardium catillus, Planorbis micromphalus*, &c. *Niphargus caspius* is very probably the "extinct Gammarid" (see Leydig, "Ueber Amphipoden und Isopoden," Zeitschr. f. wiss. Zool. xxx. p. 249) which the other species of *Niphargus* have as their ancestor.

† In many cases, no doubt, it is difficult to decide whether a certain organ is adapted to feeling, tasting, or hearing; nay, it is exceedingly probable that in many of the lower animals the faculty of touch is not separated from taste and hearing.

flagella, more resemble the species of *Gammarus*, and thus represent the more conservative element, which, indeed, is the case with the female sex generally. On the first four joints of the five-jointed main flagellum of the upper antennæ of the male are very large cylindrical organs, described by Leydig and others as olfactory organs. At their free extremities these cylinders present each an aperture, from which perhaps, as Leydig states, thin hairs may actually be exserted; and from within a nervous branchlet penetrates into each cylinder, and forms a cellular inflation (in the cylinder itself) only to disappear immediately afterwards, as I have observed still better in living examples of another species, namely *Gammarus priscus*, at Krasnovodsk. On the secondary flagellum of *Niphargus caspius*, as also on the last joint of the peduncle of the inferior antennæ, we find peculiar organs, constructed like the olfactory pencils of *N. puteanus*, as described by Aloïs Humbert: these are large and resistant rods, the somewhat acute extremities of which are beset with a great number of very thin and long chitinous hairs. In the interior of each such rod runs a nerve, which, before entering into the rod, swells into a nerve-cell with a nucleus. But whether this nervous branchlet breaks up into still finer ones, which penetrate into the chitinous hairs, I have been unable to see, although I have employed a magnifying-power of 1500 diameters and various reagents. From their organization I should not interpret these pencils as essentially and exclusively auditory organs, but as extremely sensitive organs of touch, capable of perceiving the very slightest movement of the surrounding medium.

These olfactory and tactile (or auditory) organs, which are certainly comparatively very highly developed, may enable the animal to dispense with eyes in the dark sea-depths inhabited by it; and they are thus in course of degeneration, although they have not yet completely disappeared—in part, perhaps, because they may still be made use of, for example, in ascending to depths of 35 fathoms.

Matters are very different with the species of *Onesimus*, of which we may take for consideration *Onesimus caspius* as the most typical.

The eyes of *Onesimus caspius* are small, irregularly oval, widely separated from each other, and completely unpigmented, so that they are not at once distinguishable even under the microscope. It is well known that the unpigmented eyes of many Gammaridæ living at great depths become reddened under the action of sunlight; but this does not occur in *O. caspius*. We are justified in assuming that even if the species

of *Onesimus* are not entirely deprived of the faculty of sight, their eyes do not function in the medium which usually harbours them, *i. e.* in the submarine mud where they constantly dwell.

But leaving out of consideration the undeveloped eyes, we find in the species of *Onesimus* no sense-organs on the antennæ and other external parts of the body, as in *Niphargus*. Nay, the antennæ are in them even deprived almost entirely of the usual hairs, which occur only on the lower surface of the upper, and the upper surface of the inferior antennæ, and are also very minute and present in small number. On close examination, however, we find very highly developed, although concealed, sense-organs on the outer lamellæ of the maxillipedes, which have already been described or figured by different authors. These are short thick stumps with rounded ends, which stand in corresponding cylindrical depressions of the lamella, from which they usually have only the rounded portion projecting. Some of them, however, appear much longer, inasmuch as they project more and also have the extremities more acute; these are the two cylinders standing at the apex of the lamella, which present a transition towards the ordinary setæ, and thus also prove that we have to do with chitinous setæ metamorphosed for a particular purpose*. These taste-cylinders (as I will call them) stand in a row along the inner margin of the lamella, their number varying from eight to fourteen in the different species, as also probably according to the age of the individuals. In the interior of the lamella, beneath the oval matrix-cells, there runs a thick nerve-cord which sends off a branch nerve to each taste-cylinder; these branches are slightly thickened at their entrance into the cylinder, and are afterwards completely lost; but whether they form a cell in the thickened part, I have been unable to decide†. At any rate the sensitive nature of

* Similar tactile hairs with more or less developed nerves and nerve-cells occur ordinarily on the parts of the mouth of the Arthropoda—for example, among the Diptera, as is universally known. But where Prof. Wagner has detected a number of buccal apertures ("Polystomien") among them is hard to conceive, as is also the case with the "resucking" (Wiedersaugung) of the food (analogous to rumination!!) by flies, also discovered by him. However, as Wagner has found epithelial cells in the saliva of a materialized spirit, and examined the hair of a Chinese lady called up from the spirit-world (with a view to the discovery of the ancestors of the existing Pediculidæ?), we may expect any thing from him (see Wagner's and Bautleron's spiritualistic writings in the 'Russischer Bothe").

† For the investigation of these cylinders *Onesimus platyuros* and *O. pomposus*, as larger species, are more convenient than *O. caspius*; but, unfortunately, I have only a few specimens of those species.

these cylinders is so distinctly marked, that we are certainly justified in regarding them as tactile organs, and, from their position, also as organs of taste.

Thus we see that in the species of *Niphargus* and *Onesimus*, which are either blind or furnished with imperfectly functioning eyes, the defective faculty of sight is replaced by the augmented function of other organs, and even brought about thereby, in so far as these render the eyes not indispensable and their retrograde metamorphosis therefore possible. The question now arises how it happens that in the different genera different organs come to greater development; and this question is answered by observation of their life-phenomena. During my dredging investigations I have observed that the species furnished with sensitive antennæ, such as *Niphargus caspius*, although living at great depths, live in the water and not in the mud, which is proved not only by experiment after the animals have been brought up *, but also by the fact that all individuals of the *Niphargus* are greatly infested by *Vorticellæ*.

The species of *Onesimus* behave quite differently. They live constantly in the mud of the sea-bottom, and here, burrowing quickly like moles, seek their nourishment by consuming the mud which contains particles of organic matter. As a matter of course, antennæ furnished with sensitive organs can be of no service to them, since not only such delicate and fragile structures as the olfactory cylinders and pencils, but even the coarser bristles have disappeared from the outer surfaces exposed to friction against the mud, as we have already stated by indicating that in *Onesimus* such bristles exist only on the inner surfaces of the antennæ, which protect each other. But as external sense-organs could not be developed, the more concealed parts of the body had to be provided with such organs. We have already seen that in the species of *Onesimus* the setæ of the outer lamellæ of the maxillipedes are developed into sensitive organs; and although it is not yet decided whether they represent taste-organs, we cannot avoid regarding them as organs adapted to the determination of the quality of the food, which, in the subterranean life of these animals, replace the eyes, and thus also bring about their retrograde metamorphosis.

We may briefly summarize all that has been said as fol-

* The animals brought up by the dredge were always placed, first of all, in small basins of water for the purpose of the observations above indicated: but the relation of the animals to the mud is to be seen even in the dredge itself; the water-animals (as opposed to the mud-animals) do not bury themselves deeply in the mud, and are speedily suffocated in it.

lows :—In the depths of the sea, where a darkness approaching zero, although not absolute, prevails, the animals living there are either provided with highly developed organs of sight, or the eyes are replaced by other organs which acquire a considerable development. These organs, however, are developed upon different parts of the body in accordance with the external conditions and the mode of life of the animal, which must be regarded as the *primum movens* of the whole process of the degeneration of the one organ and the development of the other.

VIII.—*On the Genera of* Felidæ *and* Canidæ.

By E. D. Cope.

[Continued from p. 45.]

Canidæ.

The range of variation presented by the species of Canidæ includes several generic divisions, recent and extinct. These genera, however, are as closely intergraded as are those of the cats; and their definite characters are subject to occasional failure from abnormal variations. These, however, are not so frequent as to invalidate the classification to which they form the exceptions.

The Canidæ appeared in the Upper Eocene period; and the genus *Canis* was well represented by species in the lowest Miocene in Europe and the United States. The other genera are represented by fewer species; and many of them are extinct. The foxes (*Vulpes*) are the most numerous of them; and but few extinct species of them are known. America presents us with the greatest variety of genera, as *Enhydrocyon*, *Temnocyon*, and *Palæocyon* extinct, and *Icticyon*, extinct and recent. *Speothus*, extinct in America, still exists in Asia.

The most complete catalogue of the species of Canidæ is that of Dr. Gray. In his work the author brings together observations of various naturalists, and adds a number of his own. He admits a large number of generic divisions; but many of these, like those of his Felidæ, are simply founded on specific characters. A few good genera, however, exist; and a synopsis of their characters is given below. The genus *Megalotis* is here excluded from the Canidæ on account of the